Brookhaven National Laboratory
Sustainability Program

2nd Workshop

Energy for Sustainable Science

at Research Infrastructures

CERN Geneva, Switzerland

23-25 October 2013

Ed Murphy

Chief Engineer

Manager, Energy & Utilities Division

Facilities and Operations

BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

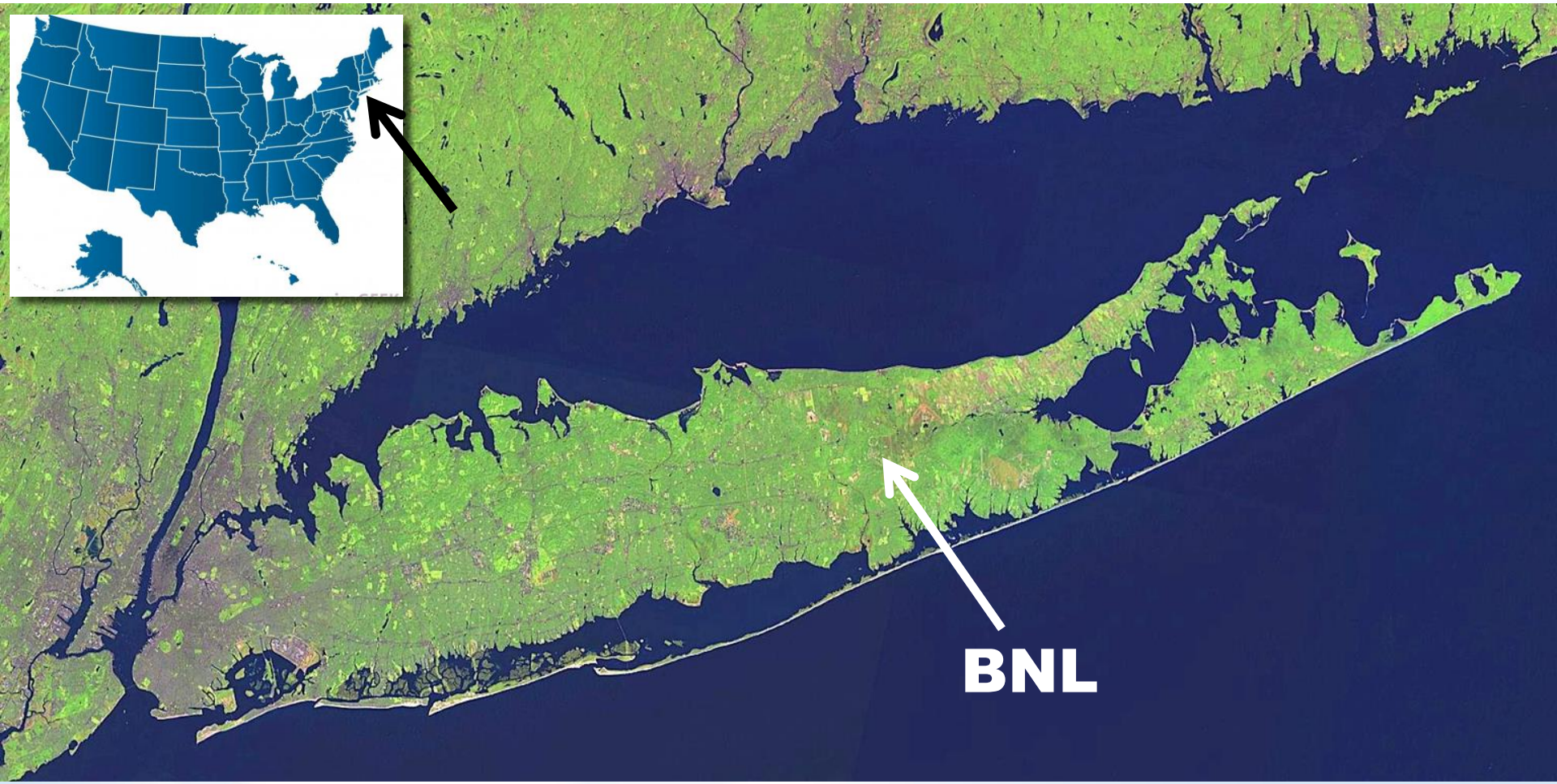
Topics

- BNL Overview
- Energy and Carbon Footprints
- Energy and Sustainability Accomplishments
  - Long Island Solar Farm at BNL
  - BNL Hydroelectric Power Contracts
  - Chilled Water Thermal Storage
  - LEED-certified Research Facilities
- Site Sustainability Goals and Plan
  - Investment Strategy
- Future Vision

BNL Overview

Brookhaven National Laboratory

Upton, Long Island, New York, USA 11973



Brookhaven National Laboratory

A passion for discovery

2153 ha

321 buildings

450,000 m^2

56 km paved roads

19 km sidewalks

Housing for 550

3000 employees

> 4000 guest users per year

FY 10	FY 11	FY 12	FY 13
$700M	$769M	$747M	$744M

Major Research Areas and Facilities

National Synchrotron Light Source

National Synchrotron Light Source II

Center for Functional Nanomaterials

- Photon Sciences
- Nuclear & Particle Physics
- Energy
- Environment & Life Sciences
- National Security

Relativistic Heavy Ion Collider

New York Blue Supercomputer

Energy and Carbon Footprints

Brookhaven National Laboratory
Energy Use
FY2012

1 BBtu ≈ 1000 GJ

Electricity

278,043 MWh

949 BBtu
59%

15,034 MWh

51 BBtu
3%

1,640 MWh

6 BBtu
0.4%

189,145 MWh

645 BBtu
40%

Chilled Water

Process

Natural Gas

580,879 MCF

599 BBtu
38%

Steam

72,223 MWh

246 BBtu
15%

Steam

Buildings

Oil/LPG

234,388 Gal.

32 BBtu
2%

No. 2
57,615 Gal.

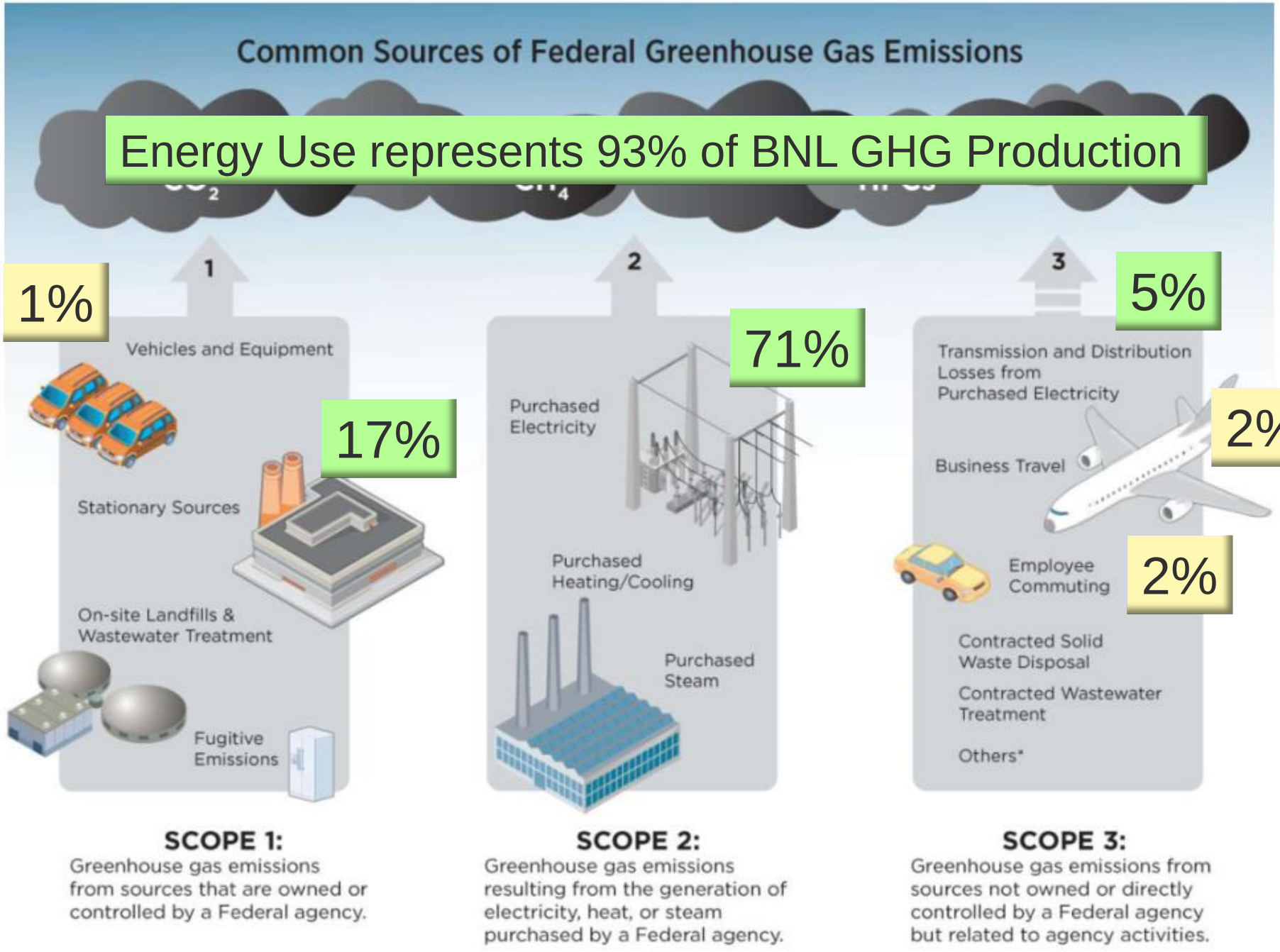
Bio-Diesel
51,226 Gal.

7.99 BBtu
0.5%

6.92 BBtu
0.4%

Total Energy: 1616 BBtu

Non Fleet Vehicles & Equipment

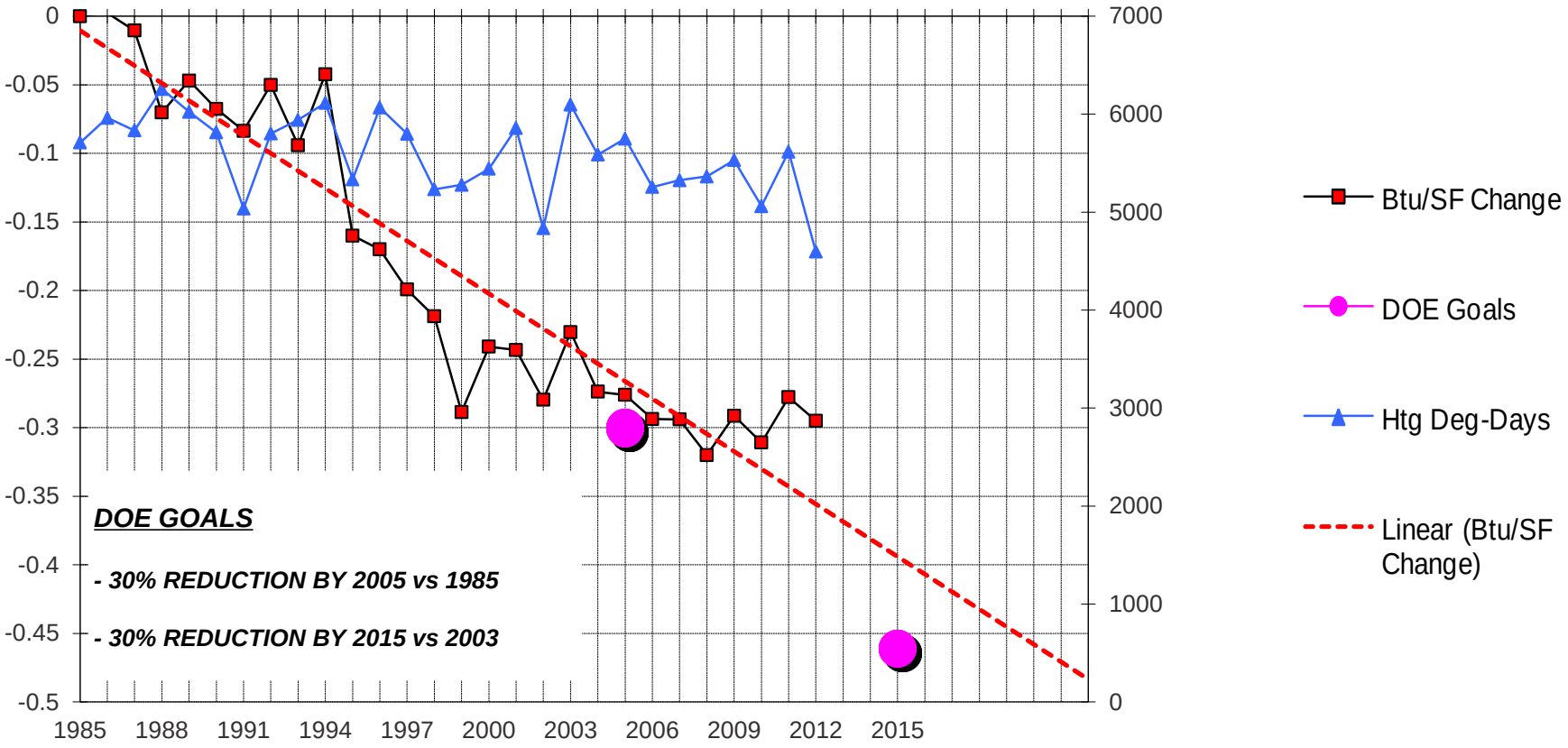

Common Sources of Federal Greenhouse Gas Emissions
Energy Use represents 93% of BNL GHG Production
1%
1
Vehicles and Equipment
17%
Stationary Sources
On-site Landfills & Wastewater Treatment
Fugitive Emissions
SCOPE 1:
Greenhouse gas emissions from sources that are owned or controlled by a Federal agency.
71%
2
Purchased Electricity
Purchased Heating/Cooling
Purchased Steam
SCOPE 2:
Greenhouse gas emissions resulting from the generation of electricity, heat, or steam purchased by a Federal agency.
5%
3
Transmission and Distribution Losses from Purchased Electricity
2%
Business Travel
Employee Commuting
2%
Contracted Solid Waste Disposal
Contracted Wastewater Treatment
Others*
SCOPE 3:
Greenhouse gas emissions from sources not owned or directly controlled by a Federal agency but related to agency activities.

BNL's Energy Efforts – Some History

- BNL has a long and successful history of identifying and implementing energy conservation projects
- Began an energy conservation program in 1973 to combat high energy costs (first oil crisis)
- Over $60 million has been invested in a wide range of efforts that has curbed BNL's energy consumption dramatically
- Energy intensity (Btu/GSF) has been reduced by over 54% comparing FY2012 to FY1973
  - Saves about $15 million/year in energy costs
  - Over 110,000 $MTCO_2e$ per year avoided

BUILDING ENERGY PERFORMANCE

BTU / FT² Change (%) vs. Baseline Years



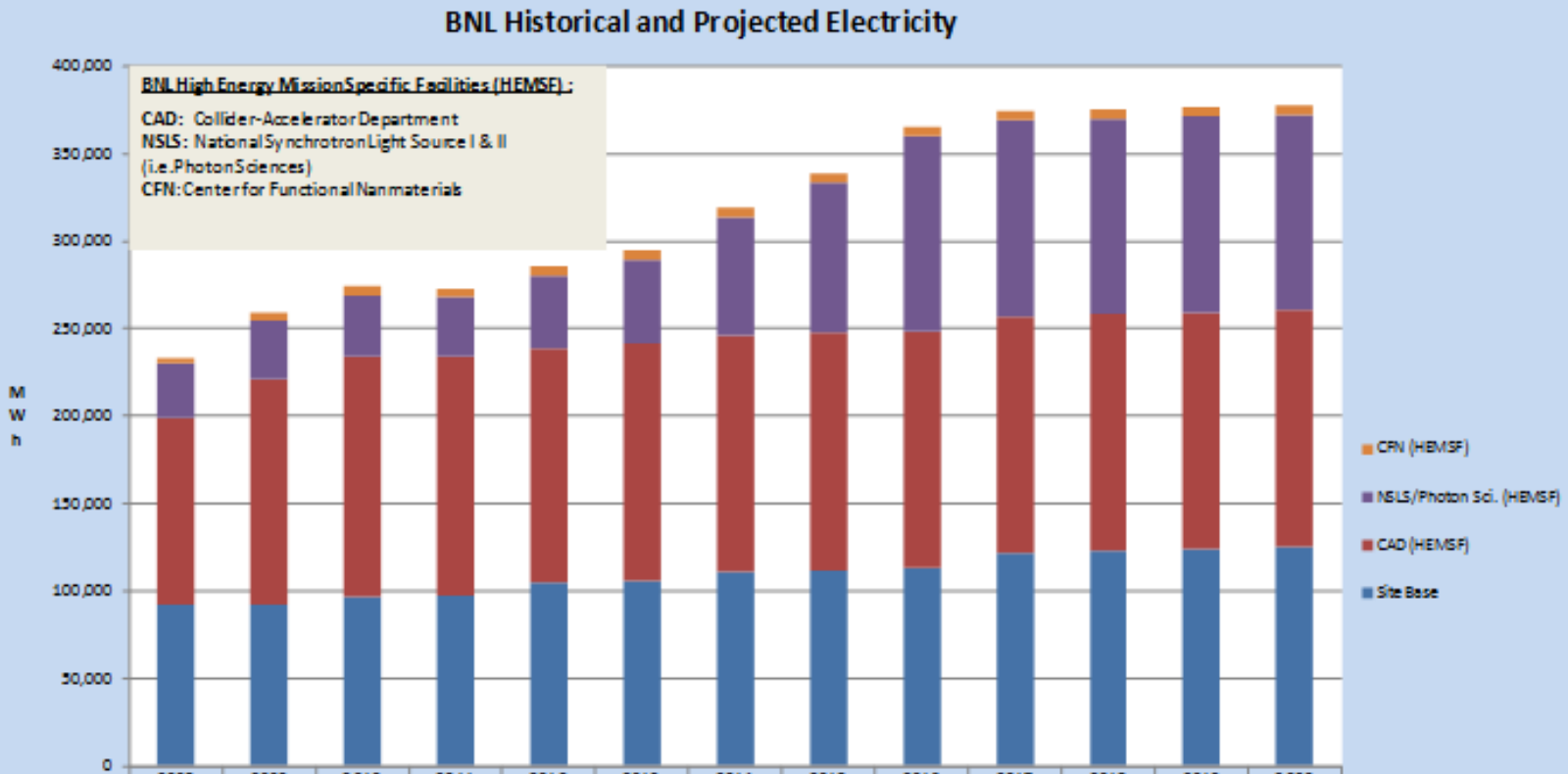
BNL Energy Usage

- BNL's electricity use is driven by research budgets and operation of our accelerators and research facilities. "Base load" follows with site activity.

Total purchased electricity is estimated to increase over 60% by 2020 compared to 2008 levels.

BNL has developed a preliminary plan in the SSP to reduce/offset the estimated increase in Greenhouse Gas (GHG) emittions to meet or exceed the 28% reduction target by 2020 as compared to the base year of 2008, for a total reduction/offset of ~115%.

BNL's sustainability initiatiive will require major infrastructure investments.



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CFN (HEMSF)	3,000	4,500	5,100	5,300	5,398	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400
NSLS/Photon Sci. (HEMSF)	30,665	33,313	35,192	34,146	41,708	48,164	67,560	85,848	111,778	111,778	111,778	111,778	111,778
CAD (HEMSF)	107,078	129,248	136,687	136,626	133,560	135,200	135,200	135,200	135,200	135,200	135,200	135,200	135,200
Site Base	92,304	91,902	96,923	96,991	104,826	106,030	110,892	112,074	113,257	121,798	122,981	124,163	125,346

BNL Energy and Sustainability Accomplishments

Long Island Solar Farm at BNL

- DOE and BNL made the BNL site available to host a major solar PV array
- The project executed through a Request for Proposal from the local utility (Long Island Power Authority)
- About 80 ha (200 acres) of federal land was made available through an easement
- The project began commercial operation in November 2011, produces 31.5 MW peak, and avoids ~31,000 tons of carbon per year
- Both commercial array and a 1 MW BNL array will be utilized by BNL research programs

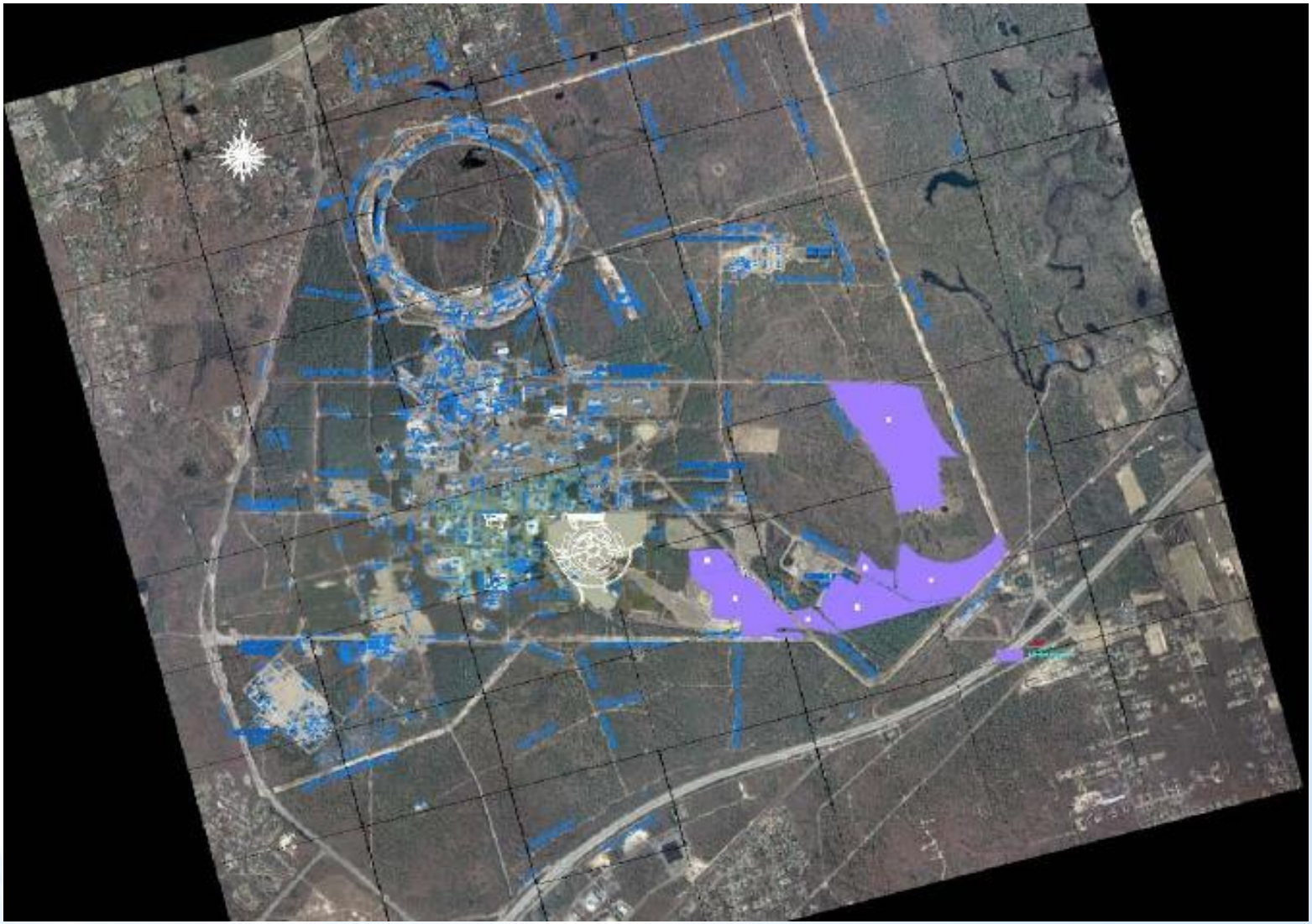
LIPA Long Island Power Authority

bp solar

MetLife

U.S. DEPARTMENT OF ENERGY

Long Island Solar Farm at BNL



LISF: Estimated Output and Cost

Long Island Solar Farm (LISF)

LIPA PPA Payment Agreement*	$	298,000,000	
Installed construction cost (no OH&P)	$	165,000,000	
Construction cost only	$	5,238	/kW

			PPA		
kW	Est kWh/yr	Est. Cap Factor	Term (yrs)	kWh	Ave. $/kWh
31,500	44,000,000	0.16	20	880,000,000	$ 0.34

Notes:

PPA includes financing, OH&P, O&M and tax credit

Construction cost indicated is not confirmed

1 kWh = 3.6 MJ

NYPA Hydroelectric Power Contract

- On March 1, 2011, BNL began receiving 15MW of hydropower from NYPA
  - 120,000,000 kWh / year (45% of BNL power)
  - "Wheeled" to BNL from upstate New York
  - New York State allocates this power to encourage economic development
- The power costs less than $0.05/kWh
  - No capital investment for BNL
  - Capital recovery is in the electric rate
- Inexpensive electricity enables BNL's accelerators to run longer– more research
- Hydropower is renewable!
  - Some consider it not "green" enough…
  - Reduces GHG emissions by approximately 78,000 $MtCO_2e$ per year (compared to local fossil mix)

New York Power Authority

Chilled Water Thermal Storage

- BNL's 7,200-ton (25,000 kW) Central Chilled Water Plant includes Chilled Water Thermal Storage
  - 11,400,000 liters of chilled water
  - Stratified tank (maintains thermocline)
  - 22,000 ton-hours (280 GJ) thermal storage at 10^{o}F (6^{o}C) delta-T
- Total construction cost = $3.5 million
- Benefits of thermal storage:
  - Avoids $400,000/year of electric cost through day / night demand shifting
  - Provides additional chilled water capacity for peak summer days (BNL capacity constrained)
  - Provides reliable chilled water supply to critical process (computer) loads

BNL's New Buildings Meet Leadership in Energy & Environmental Design (LEED)

- USGBC rating system that focuses on sustainable design:
  - Sustainable Site Development
  - Water Efficiency
  - Materials & Resources
  - Energy & Atmosphere
  - Indoor Air Quality
  - Innovation and Design Process
- Center for Functional Nano-materials (CFN) & Research Support Building (RSB) both obtained Silver
- Interdisciplinary Science Building Phase I (ISB) is going for Gold

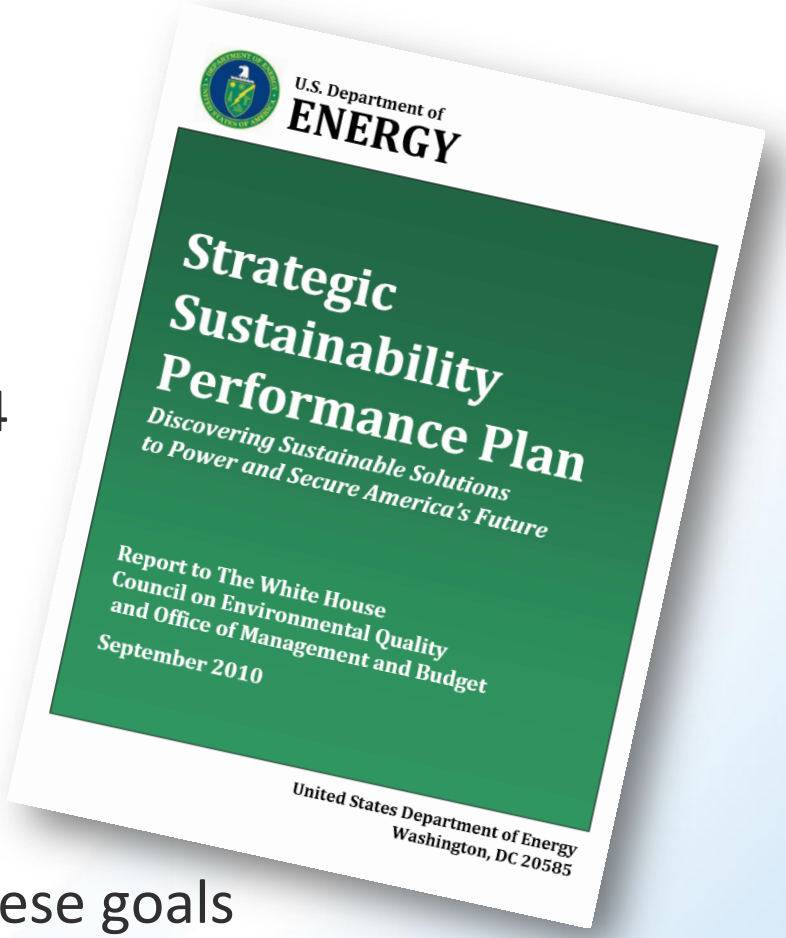
NSLS-II LEED Status

- **The NSLS-II is registered under two LEED projects**
  - $912 million facility
- **Ring Building – LEED Silver**
  - 37,000 m^2 "process" facility
  - Houses electron accelerator & experimental beam lines

  - Features process cooling design that substantially reduces use of refrigeration by increased operating temperatures; "free cooling" via cooling tower
- **Lab-Office Buildings (LOBs) – LEED Gold**
  - Five (5) identical, 3,700 m^2 buildings contiguous to Ring Building
  - Optimized features for labs and offices including: efficient envelope, lighting and controls; day-lighting; high reflectivity roof; recycled and regional content; enhanced commissioning and monitoring; 34% energy reduction (ASHRAE 90.1 2004)

Site Sustainability Goals and Plan

DOE Background



- DOE has developed a Strategic Sustainability Performance Plan in response to Executive Order 13514
- The plan establishes Department goals in a wide variety of areas of sustainability
- DOE requires each laboratory to develop and implement a Site Sustainability Plan to flow down these goals
- BNL's first annual plan was submitted on December 31, 2010. Update for the 2014 submission is underway.

Site Sustainability Plan (SSP) – Major Goals

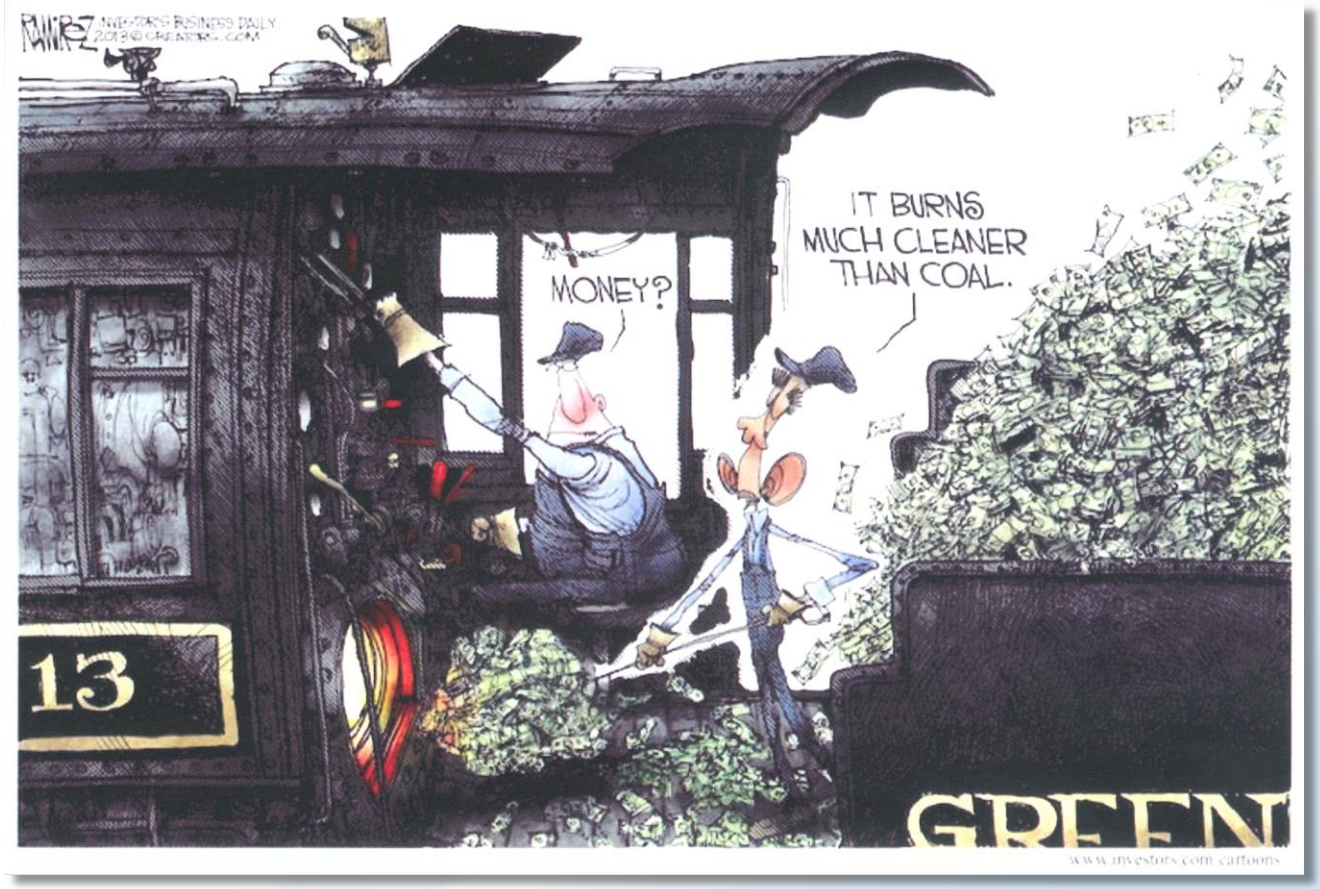
- 28% reduction Scope 1 & 2 greenhouse gas by 2020 from 2008 baseline
- 30% reduction energy intensity by 2015 from a 2003 baseline
- 7.5% of annual electricity consumption from renewable sources by 2010
- 2% per year reduction in fleet petroleum consumption by 2015 relative to 2005 baseline
  - 30% reduction vehicle fleet petroleum use by 2020 from 2005 baseline
- 10% per year increase in fleet alternative fuel consumption from 2005 baseline
- 75% of new light duty vehicles purchased must use alternate fuel by 2015
- Every site to have at least one renewable energy generating system by 2010
- 100% new facilities “net-zero” energy after 2030
- 16% water intensity reduction by 2015 from a 2007 baseline; 26% by 2020; 20% reduction in industrial / other water use by 2020 from 2010 baseline

Sample of Current Sustainability Actions

- Energy Conservation Projects: Phase I (UESC)
  - Lighting upgrades (17 buildings)
  - Enhanced energy controls and retro-commissioning (10 Buildings)
  - Chiller efficiency project
  - Implemented with a Utility Energy Service Contract (UESC)
- High Performance Sustainable Buildings (HPSB)
  - Upgrade 18 existing (older) buildings to meet LEED HPSB standards
  - Computer / data center efficiency improvements
- Renewable Energy
  - Hosting the Long Island Solar Farm
  - Purchasing Renewable Energy Credits (REC's)
  - Northeast Solar Energy Research Center (NESRC)

Sustainability Programs Must Conserve Scarce Capital

- Capital is a very constrained resource
- Useful for solving all kinds of problems
- Do "biggest-bang-for the-buck" projects
  - Most energy savings
  - Most reliable
  - Most available
  - Most environmental benefit / $ invested
  - Economic paybacks



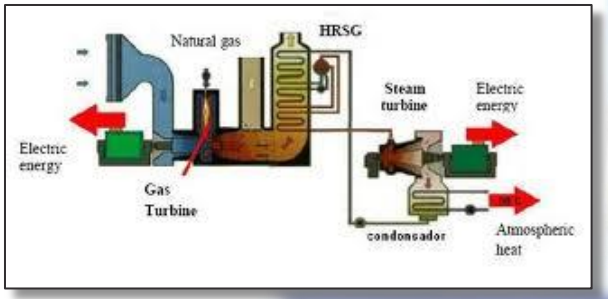
- Technical experts must help separate the reality from the "hype".

Future Vision

Future Sustainability Actions (Cont'd)

- Energy Conservation Projects: Phase II (UESC)
  - Lighting upgrades, enhanced controls, retro-commissioning
  - Steam system improvements

- Combined Heat and Power Plant (CHP)
  - Cogeneration of electric power and steam



- Other Initiatives
  - Modernization of the BNL site
  - Chilled water storage increase
  - Small wind and solar PV projects
  - Biomass evaluations
  - Alternatively fueled vehicles
  - Reduction of waste
  - Employee engagement and outreach

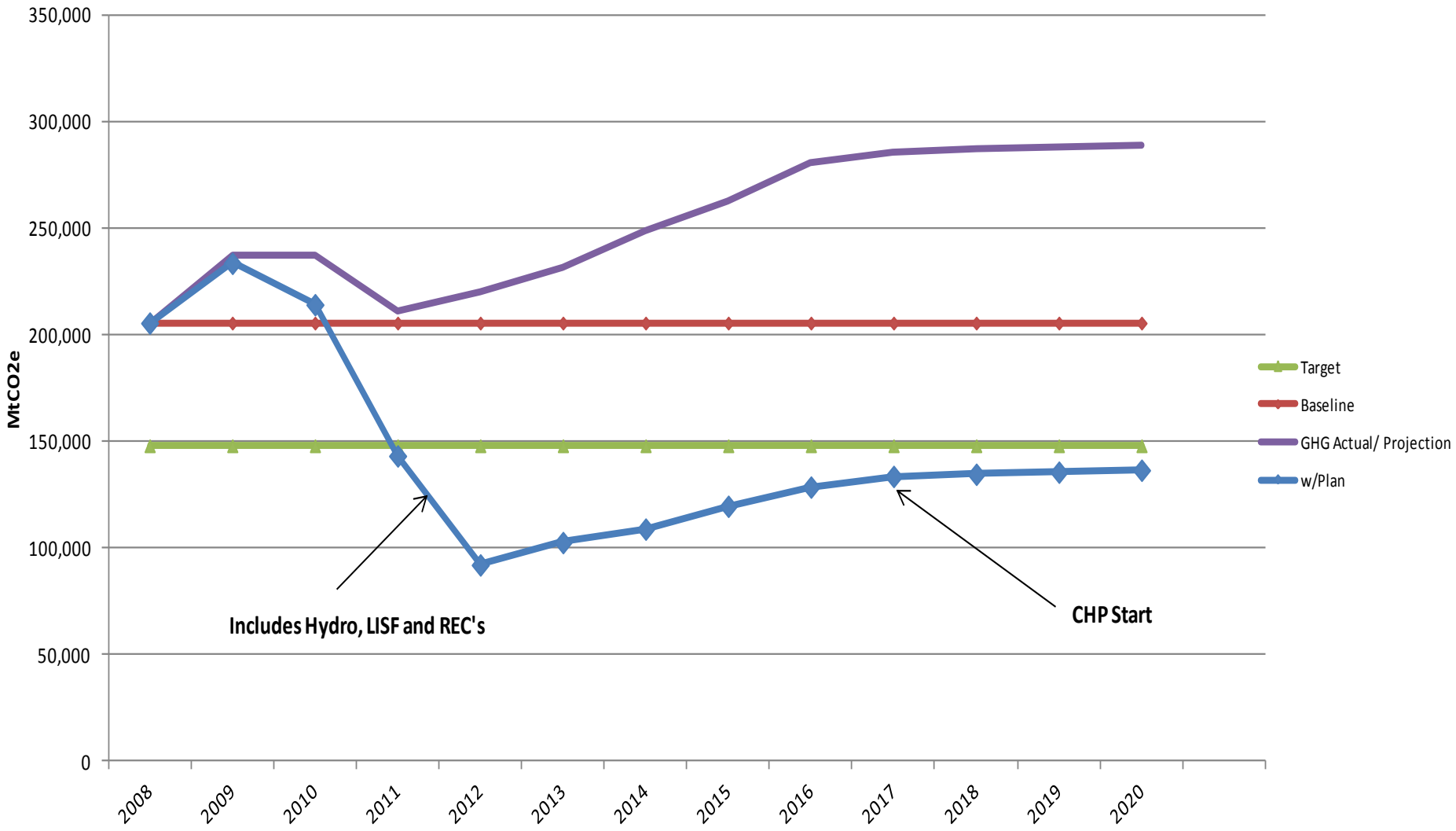
BNL's Vision Integrates Science and Sustainability

- BNL Sustainability Steering Committee
  - Senior leadership from:
    - Research
    - Facilities & Operations
    - ES&H
    - Communications / Public Affairs

- Leverage 32 MW Solar PV Project
  - Currently the largest solar PV project in the Northeast
  - Northeast Solar Energy Research Center (NESRC)
- Other major energy research initiatives
  - Biofuels
  - Energy storage / Batteries
  - Advanced Electrical Grid Innovation, Information and Support Center (AEGIS)
  - Smart Grid research

- Continue to seek the most economical / environmentally friendly energy for BNL

Brookhaven National Laboratory - GHG



Brookhaven National Laboratory

A passion for discovery

Questions?